Arsenic Removal from Drinking Water

Environment Energy Technologies Division

October 2005

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Financial support from:

LBNL Technology Transfer Office, Blue Planet Run Foundation, Cal Energy Commission, and AwwaRF

Background: Arsenic in Drinking Water

- Arsenic poisoning will cause about 10% of future adult deaths in Bangladesh (pop ~130 million)
  - — unless something is done
- About 60 million people in Bangladesh exposed to >50 ppb arsenic in drinking water
  - — EPA standard for drinking water = 10 ppb
- Arsenic poisoning causes:
  - — first, painful and debilitating lesions on palms and soles of feet, vascular disease leading to gangrene and amputations
  - — then skin cancers
  - — then cancers of lung, kidney and bladder
  - — death

Background (cont'd)

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Grade 2A

Grade 2C

Grade 6B

Grade 6B

Examples of various grades of Arsenic poisoning. Hyperkeratosis of palm and soles (left and center), Followed by painful sores (right)

Current (October 2005) Status

- LBNL media*: coal bottom ash coated with ferric hydroxide

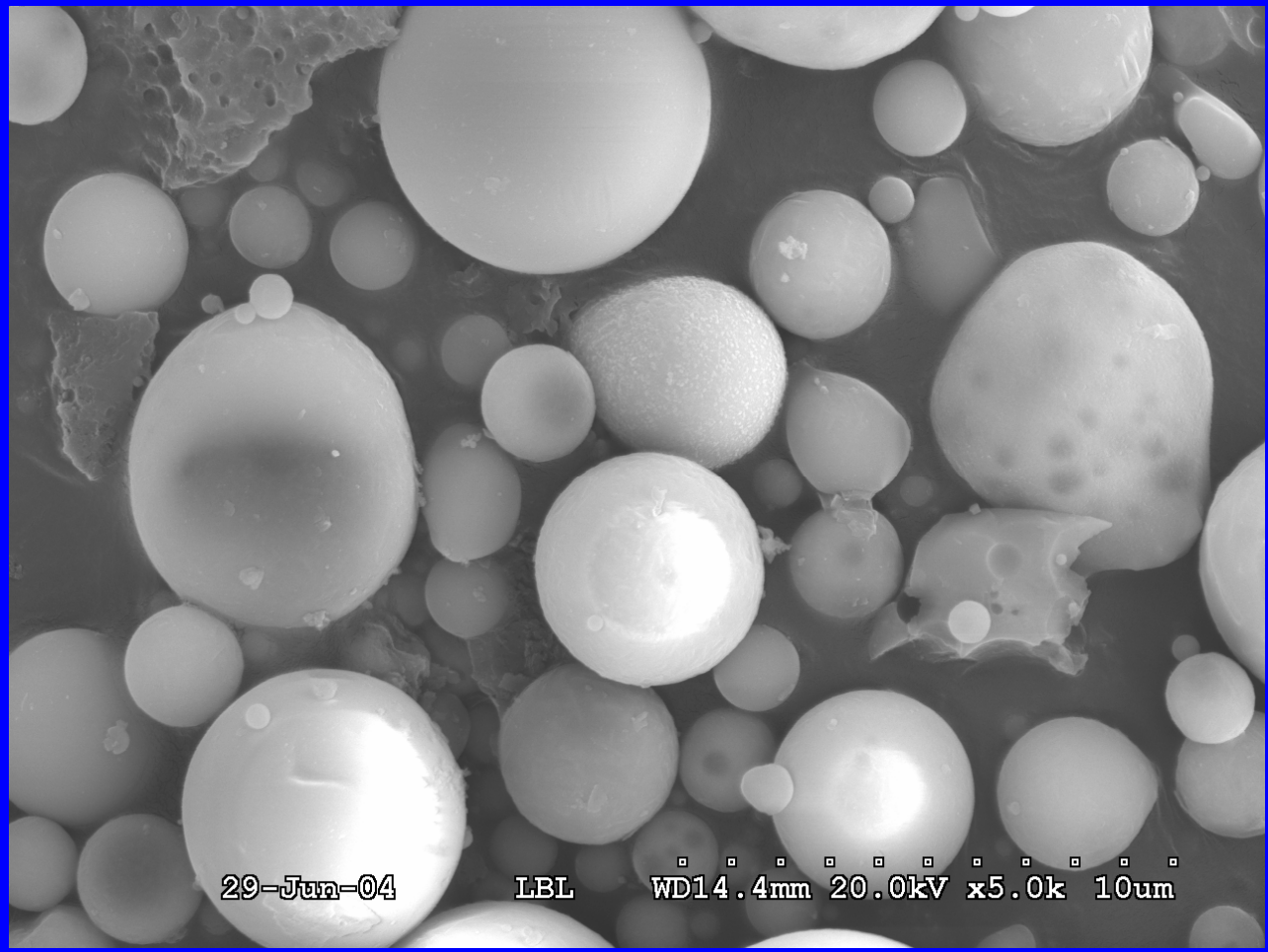
  **(patent pending)*

- Coated coal ash removes arsenic from drinking water via surface chemistry

- Coal ash is an inexpensive waste product from power plants ($4 per 1000 kg)

- Tests show high removal capacity (later slides)

Untreated coal ash (micrograph)



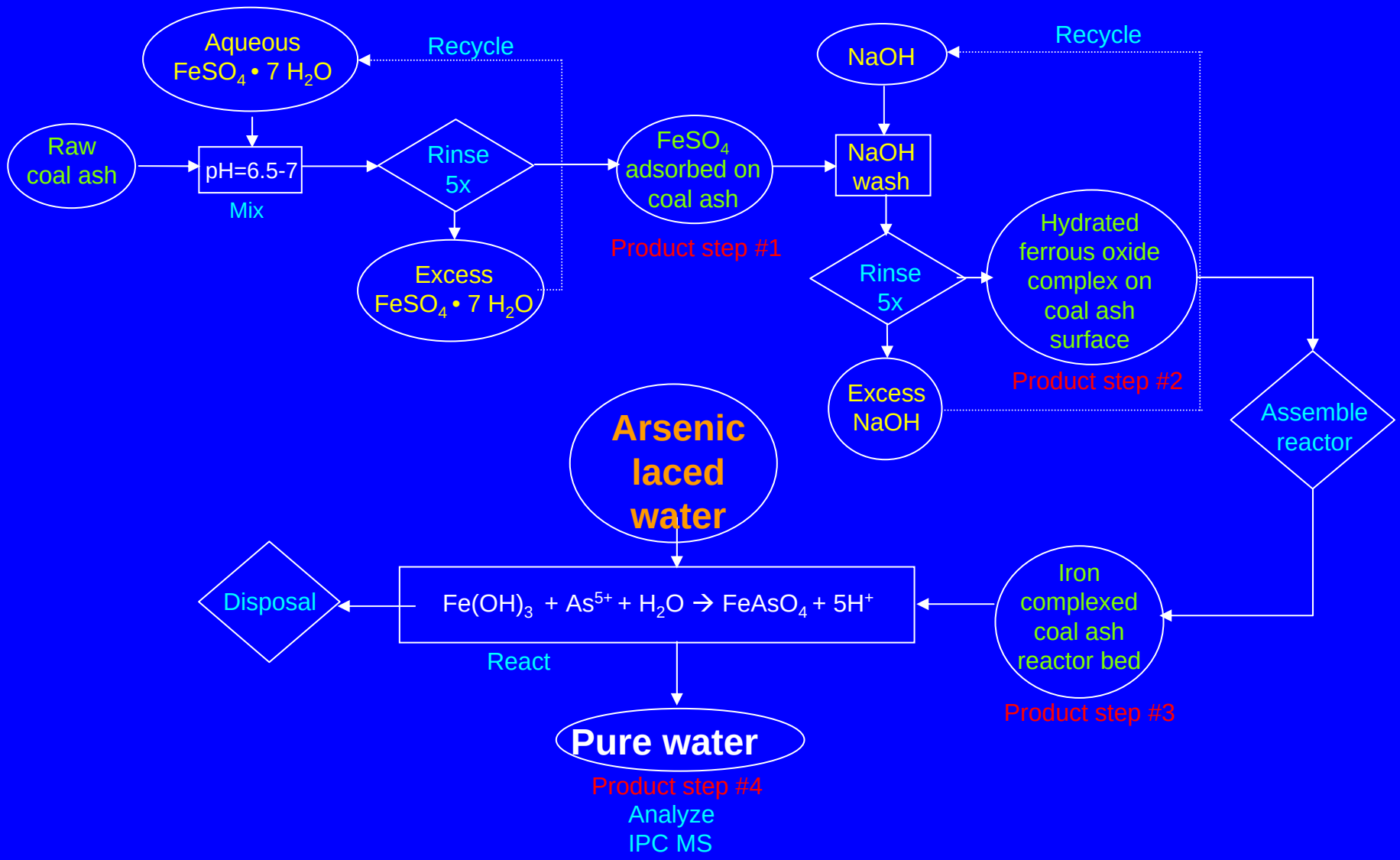
Pre-process the water

- The Arsenic in the ground water is trivalent
- First convert it to pentavalent with atmospheric oxygen
- Under UV light (for example with UV fluence in UVWaterworks), this takes fraction of a second, otherwise several minutes

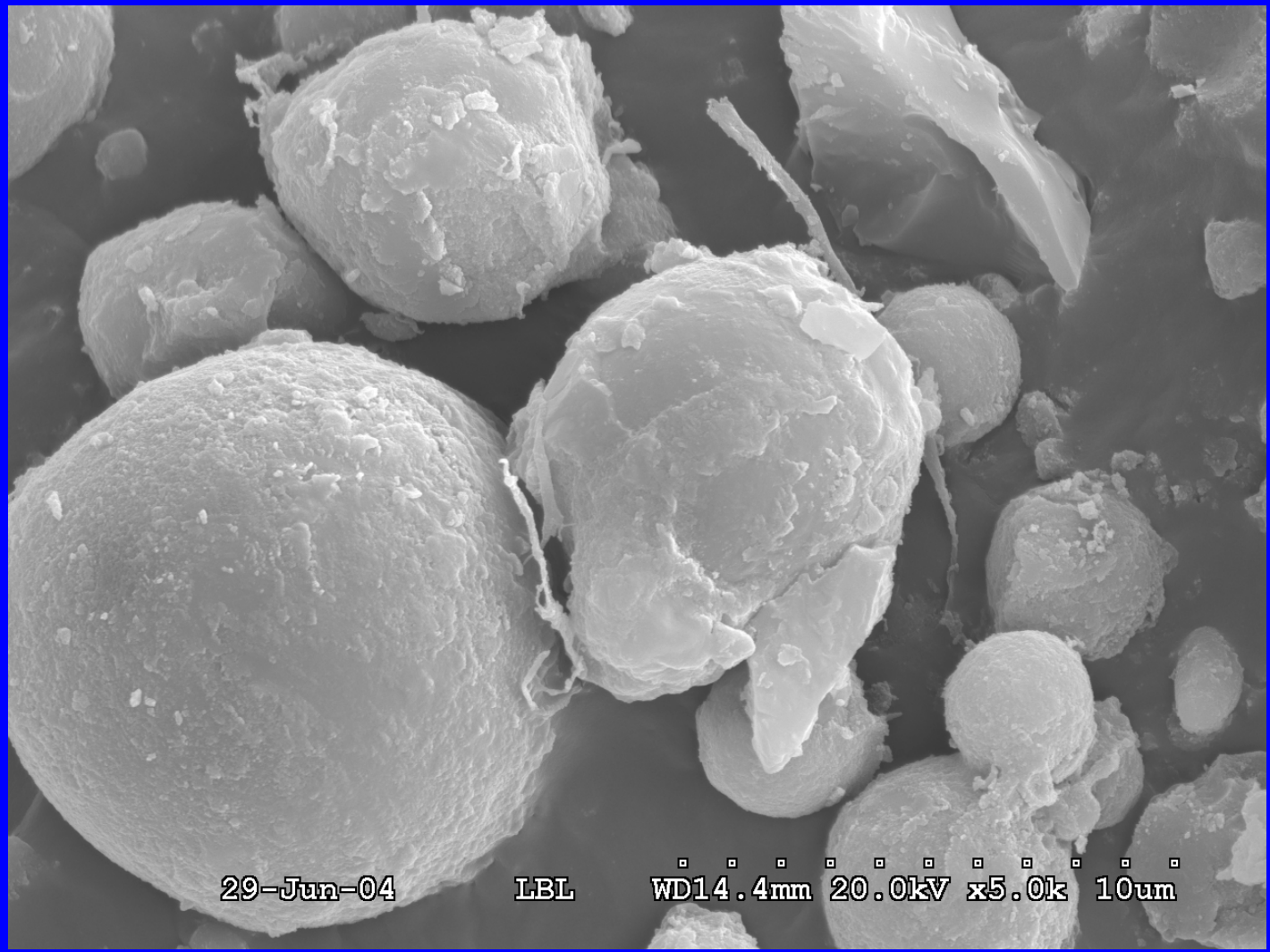
$$As^{3+} \rightarrow As^{5+}$$

Process Chemistry*

(*patent pending)

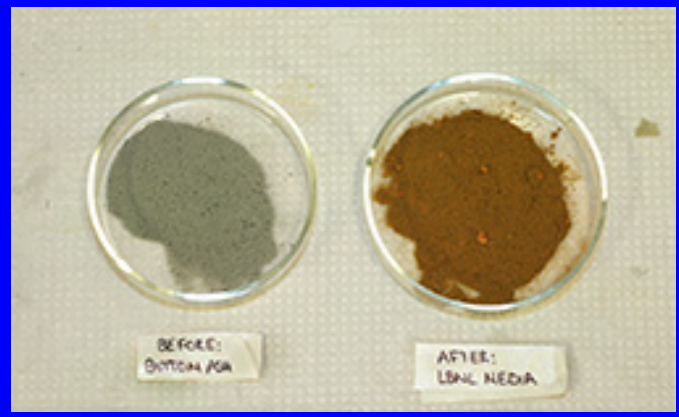


$Fe(OH)_3$ -- Coated Ash (micrograph)



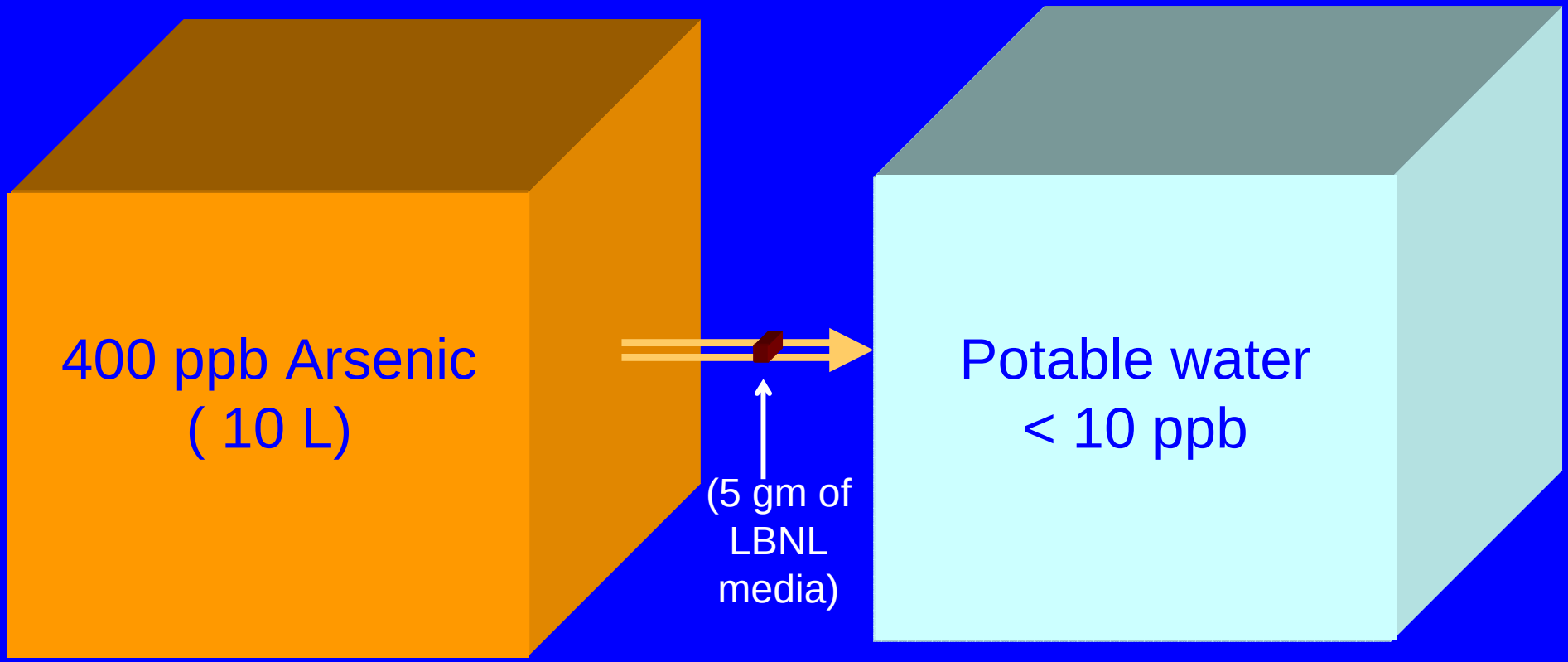
Coal ash coated with Ferric Hydroxide

Photograph showing bottom ash before coating (left), and after coating (right) with Ferric hydroxide



Arsenic-laced water mixed with coated ash, being filtered to test arsenic removal capacity of the coated ash.

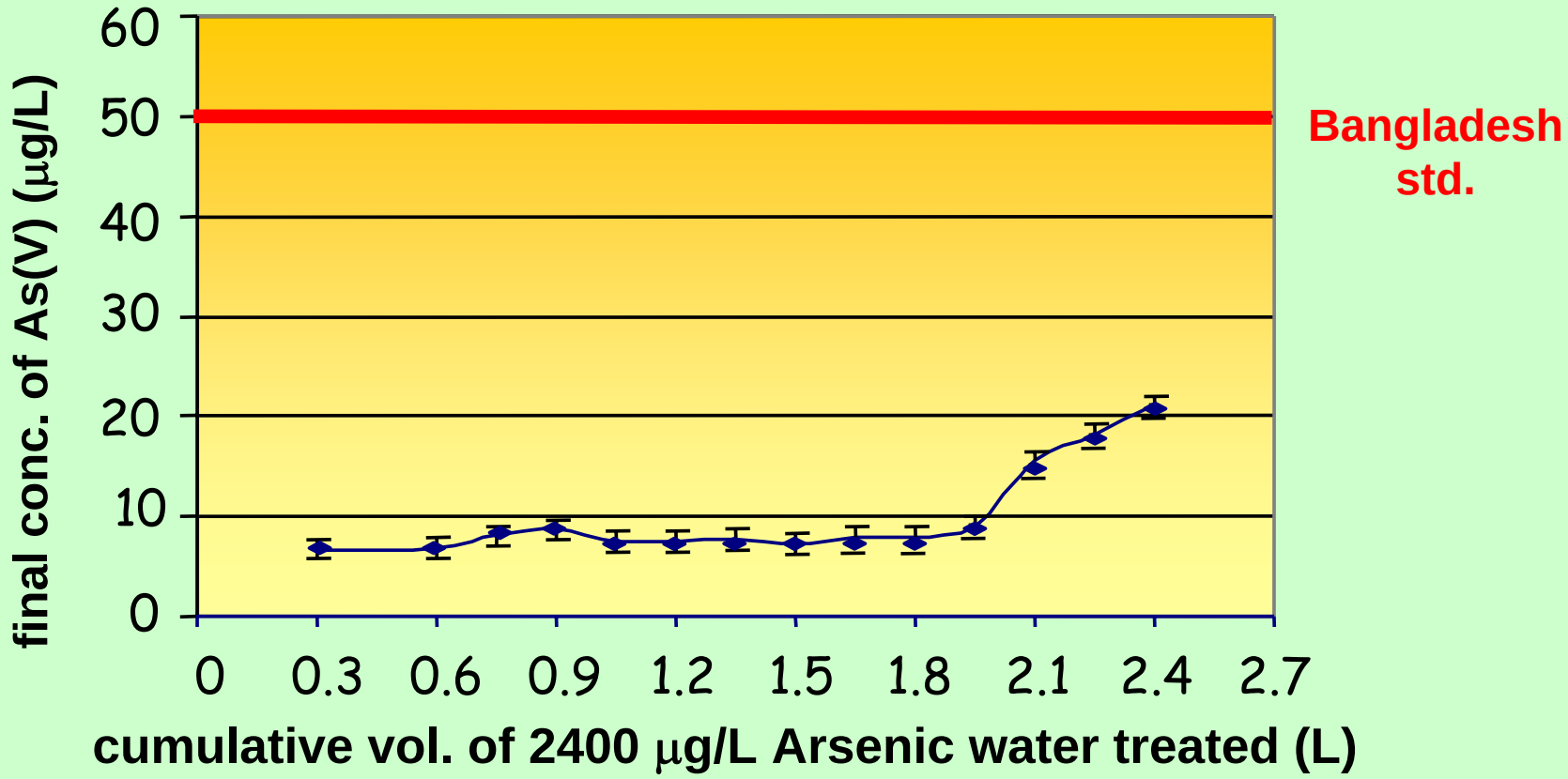
Results Summary



10 L = volume of drinking water /person /day

Capacity of LBNL media for Arsenic

Removal capacity of 5g of LBNL media



Capacity of LBNL media for Arsenic

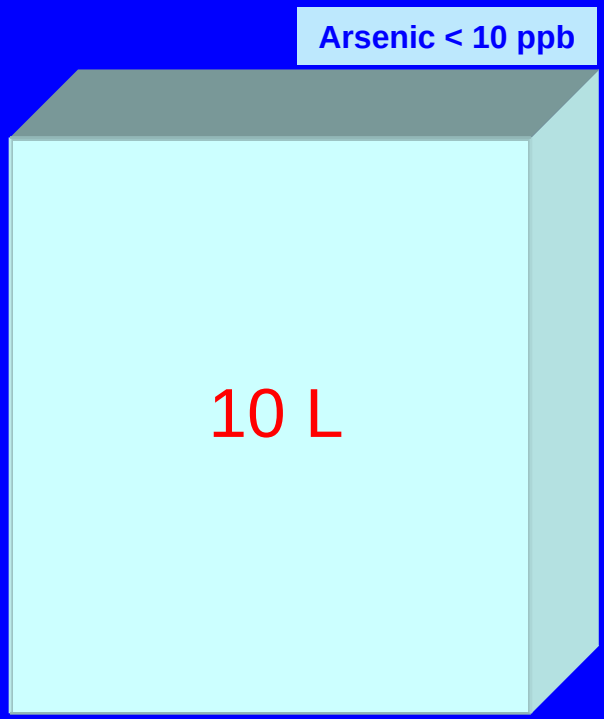
So, from previous slide, 5 g media reduced arsenic from initial 2400 ppb to less than 10 ppb in 2 L water.

Thus, 5 g media removed about 4.8 mg elemental arsenic, or a capacity of about 0.95 mg elemental arsenic per gram of ARUBA

For design calculations, we conservatively assume a capacity of 0.7 mg per g of media

Advantages of LBNL Method

Amount of water (400 ppb arsenic) treated by 5 g of media



LBNL medium
(modified coal ash)

Best competing medium
(modified crushed bricks)

(LBNL media also cost less per gram)

Cost estimates

- **Material cost to make LBNL media (weight 2 kg) is US$ 0.06 per person per year**
  - **assuming 10 liters / person / day drinking water consumption**
  - **400 ppb inlet arsenic concentration**
  - **10 ppb outlet arsenic concentration**

- **After including reasonable* business costs (handling, transport, storage, delivery, and margins for distribution and retailing), and excess media spent to overcome interference, LBNL media cost should still be < US$ 2.00 per person per year! (Reactor costs not included)**

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* Reasonable business costs estimation: We start with cost of clean, iodized, finely ground table salt (from comparably cheap raw materials). Such salt retails in India for US$ 0.17 / kg. (Coarse raw salt retails for US$ 0.09 / kg.) We assume business costs for the media will be proportional (by weight) to table salt.

Technology Comparison for treating 1 year's supply: 3650 L of 400 ppb water

Current best affordable system	Potential future system
IDE-International's "Shapla" filter	LBNL's media
Needs: 36.5 kg of media / yr	Needs: 1.6 kg of media / yr
Retail price: US$ 9.70 in Bangladesh	Retail price: (estimated) less than US$ 2.00 in Bangladesh
Delivers: < 50 ppb arsenic	Delivers: < 10 ppb arsenic

Next Steps

- Identify and secure funding for further research!
- Optimize reaction conditions (chemistry)
- Test for interference from other solutes in source water (chemistry)
- Develop, design and test reactors (engineering)
- Field test and optimize reactors based on feedback
- Explore safe ways to dispose of spent media
- Follow up on interest (conditional on research success) from potential partner institutions